AN ASSESSMENT OF WATER KNOWLEDGE AMONG 4TH, 6TH, AND 8TH GRADE STUDENTS

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CHAPTER I

NATURE OF PROBLEM

Introduction

Loren Eisley wrote, "If there is magic on this planet, it is water" (Miller, 1982). Water is the most unique and abundant substance on the planet earth, a substance so common, yet its importance is beyond measure since it is the catalysts for all life. Even humans with all our technology and ingenuity can not survive without water. Not until earth is viewed from space do we see our planet in its proper perspective. "We see a bright world of blue water framed by the black of space and partly concealed by lovely patterns of white water vapor clouds. In the Polar regions is the glitter of frozen water. Through breaks in the cloud patterns the continents are visible, shapes of brown and green interrupting the blue of oceans. As the earth turns, it becomes evident that the continents are islands in the global sea that gives earth its unique character" (Goodwin and Schaadt, 1978).

Our lives and our fortunes depend on the availability of fresh water. One hundred years ago, development of the

West by settling pioneers depended upon wells or springs. Fresh water was carried by hand and gutters were used to collect rainwater which was stored in cisterns to be used for bathing, washing clothes, and even drinking. Since then, the world, as well as the United States, population has dramatically increased and so has the demand for fresh water. In the United States the daily domestic use of fresh water is nearly one hundred gallons per person (Miller, 1982). However, domestic use of fresh water accounts for only about ten percent of the total amount of water used daily. Most of the rest is used for irrigation and industry. Each new generation further increases the demand for fresh water.

Less than one percent of the earth's water is fresh and easily accessible. Since the world supply of water is fixed and the supply of fresh water is limited, water concepts, methods of protecting water, and methods of managing and using water resources must be explored and taught. The emphasis on education about water problems is relatively new. The importance of water to the quality of life has been shadowed by what might appear to be greater urgencies, i.e., air pollution.

Misuse and damage to the water environment is a matter of slow accumulation. When change is slow, it is often not noticed by the untrained observer. Consequently, we can arrive at a time of urgency so gradual that only those intimately involved with the world of water would be aware of the problem or crisis. Awareness is essential for all the population, not just the trained expert. There is a need for better water knowledge as indicated by a study that was conducted to assess water knowledge of college bound high school graduates (Mills, 1983). The study found students were specifically not knowledgeable in the area of water resource management.

One goal of education should be to develop an understanding of water and its resources that will enable persons to make competent and reliable decisions about water and its management. We need trained teachers, good textbooks, and the inclusion of water in the public school curriculum. To reach this goal, a closer examination of current trends in water education must be made.

The focus of this study is investigating children's water knowledge. The educational significance of gaining more water knowledge has merit for better instructional and curriculum development in the social sciences as well as the physical and biological sciences. Perhaps the most significant goal in gaining more water knowledge lies in the area of environmental education. As world population grows, so does the demand on all of earth's natural resources. Children must be taught the necessity of conservation and pollution control. Children also must perceive certain basic water concepts in an effort to better comprehend the need for improved water resource management. The general misconceptions children have about water prevent them from fully understanding water problems related to water quality, adequacy of supply, etc. Better knowledge of children's conceptual development will enable us to develop curriculum programs to enhance concerns for environmental and conservation ethics which will help to maintain and appreciate the world that sustain us.

Statement of the Problem

There is a common belief that learning is the result of the interaction between what the student is taught and his/her current ideas and concepts (Posner, 1982). Learning takes place when students comprehend and accept ideas as being intelligible and rational. It is not simply a set of correct learned responses but rather an activity of inquiry and a process of conceptual change. Students' learning is influenced by new ideas and processes that are encountered and observed.

The scientific phenomena associated with students' misconceptions or preconceptions of water related concepts will be examined in this study. Students often bring to school preconceptual schemes (preconceived notions formed by the child) or misconceptual schemes (incorrect, misunderstood or misinterrupted concepts) that may either match or mismatch the accepted scientific explanation being discussed. The learning of these conceptual schemes has been based on evidence available to the student which is often based on a misinterpretation of the information (Smith, 1984).

Smith (1984) presented various cognitive misconceptions that are part of a common water cycle lesson. In this lesson she clearly shows student's inabilities to mentally grasp concepts that were being demonstrated. Evidence points to external distractors such as the water boiling, steam rising or the burner itself inhibiting the child's ability to comprehend the concepts being presented. Many teachers do not realize that students are attending to too many stimuli and may be mentally left out or left behind at various places during the lesson.

Cognitive processes by which students assimilate concepts that are being taught are a very important consideration, especially when these concepts are not congruent with the student's own preconceived notions. To facilitate the development of conceptual scientific principles associated with water, the nature of developing concepts and existing preconceptions need to be identified. Research indicates that pupils' understanding of scientific terms are sometimes superficial despite the fact that they can associate correct technical terms with an event or phenomena (Osborne and Cosgrove, 1983). Identification of preconceptions and superficial knowledge of water cycle concepts is needed in developing effective teaching techniques.

Studies have been conducted using the interviewing method to determine water cycle concepts of students. These studies have involved relatively few students (less than one hundred). The focus of this study is to test a larger number of students (537) and identify their misconceptions of water related concepts using a paper and pencil test, and compare these results with the results gained from asking some similar questions in a structured interview. Identifying these misconceptions will enable classroom teachers, curriculum developers, and textbook authors to plan more effectively as they become more aware of children's learning patterns.

The Purpose of the Study

The purpose of this study is to investigate children's concept of the water cycle and other water related ideas. A Water Cycle Assessment Test (WCAT) will be used to assess children's notions of what occurs when water (1) boils, (2) melts, (3) condenses, and (4) evaporates, and also to determine students' understanding of kinetic molecular motion as applied to water. The WCAT will be used to identify and compare 4th, 6th, and 8th grade students'; (1) water concepts; (2) reading level with concept levels; (3) concepts that are understood and those that are not; and, (4) water concepts with pupils that participated in out-of-school activities such as 4-H, Scouts, summer camp with those pupils who did not participate. The study will also compare WCAT results with results from a personal interview that tested some similar concepts.

Research Questions

The following questions guided the research:

1. Is there a relationship between pupil reading levels (standardized test data) and scores on the WCAT? Do you need to be able to read to learn about water?
2. At which grade level do pupils better understand various water cycle concepts?
3. Do 4th, 6th, or 8th grade pupils have greater understanding of water cycle?
4. Is there a difference in mean WCAT scores for students who have participated in out-of-school activities, ie: 4-H, Scouts, or summer camps? Are water concepts learned in or out of school?
5. Do male or female pupils have greater understanding of water cycle concepts?
6. At what grade level are concepts introduced in textbooks?
7. Of the concepts -- evaporation, condensation, and molecular motion -- which is best understood at which grade level, 4th, 6th, or 8th?
8. What relationship exists between water concepts correctly identified on the WCAT and those correctly identified during a structured interview?

Hypotheses

The following null hypotheses are derived from questions 1-4.

HO1. There is no significant relationship between students reading level stanine on the Metropolitan Achievement Tests (MAT) and water knowledge stanine on the WCAT for the total 4-6-8 population.

HO1a. There is no significant relationship between 4th grade pupils' reading level stanine on the (MAT) and water knowledge stanine on the WCAT.

HO1b. There is no significant relationship between 6th grade pupils' reading level stanine on the MAT and water knowledge stanine on the WCAT.

HO1c. There is no significant relationship between 8th grade pupils' reading level stanine on the MAT and water knowledge stanine on the WCAT.

HO2. There is no significant difference in mean scores of all students on questions dealing with evaporation (concept 1), condensation (concept 2), and molecular motion (concept 3).

HO2a. There is no significant difference in mean scores of 4th grade students on questions dealing with evaporation (concept 1), condensation (concept 2), and molecular motion (concept 3).

HO2b. There is no significant difference in mean scores of 6th grade students on questions dealing with evaporation (concept 1), condensation (concept 2), and molecular motion (concept 3).

HO2c. There is no significant difference in mean scores of 8th grade students on questions dealing with evaporation (concept 1), condensation (concept 2), and moleuclar motion (concept 3).

HO3. There is no significant difference between 4th, 6th, and 8th grade mean WCAT scores.

HO4. There is no significant difference in mean WCAT scores of pupils who have and have not participated in Scouts, 4-H, or summer outdoor camping programs.

HO5. There is no significant difference between mean male and female WCAT scores.

Definition of Terms

For the purposes of this study, the following definitions were used.

1. Reading Level -- Reading level of the students was determined by the MAT (Metropolitan Achievement Test). The reading stanine was used from the MAT. The stanine is a range of scores that indicate a students' relative standing in the norm group according to the Oklahoma School Testing Program.
2. Water Knowledge -- Water knowledge of the students was determined by the stanine score on the WCAT (Water Cycle Assessment Test).

3. Concept of Evaporation (Concept 1) -- Evaporation is one of three water cycle concepts identified and tested on the WCAT. To determine the mean score of evaporation on the WCAT questions 1, 5, 11, 12 and 15 were averaged. The definition of evaporation is -- when energy is used to change liquid water to a gas, water vapor.
4. Concept of Condensation (Concept 2) -- Condensation is the second concept of three water cycle concepts identified and tested on the WCAT. To determine the mean score of condensation questions 7, 8, 9 and 16 were averaged. Condensation is defined as the process of changing water as a gas into a liquid.
5. Concept of Molecular Motion (Concept 3) -- The third of the three water cycle concepts identified and tested on the WCAT. The mean score of molecular motion was determined by questions 2, 18, 19 and 20.
6. Interview -- An interview of 4th, 6th and 8th grade students, where questions were asked orally, while props and demonstrations of evaporation, condensation, and molecular motion were presented to the students. The interview was an attempt to learn the depth of each students concept (McJunkin, 1988).

Assumptions

1. All teachers administered the test in a similar manner.
2. Pupils responded accurately and honestly.

Limitations

1. Due to daily schedules and communication between buildings, all students were not tested the same day.
2. The test was given during the middle of the year which might affect scores.
3. Eighth grade students do not study physical science until the last quarter of the year.
4. Eighth grade students have not studied physical science since 6th grade.
5. Data on some answer sheets were not usable due to computer scanning.
6. Due to the inability of the computer to scan some responses, the number of responses vary.
7. There was no control group, so the results can not be extrapolated beyond the population studied.

CHAPTER II

REVIEW OF LITERATURE

The intent of this study is to investigate children's knowledge of the water cycle. With the ever increasing demands on the availability of fresh water we need to be concerned with educating students about water. To better understand water and how best to educate children, a review of literature emphasizing ways children learn science concepts is presented. This chapter is divided into three sections: (1) formation of concepts, (2) teaching strategies and (3) conceptual obstacles to effective teaching. The literature presented in this chapter spans the years from 1978 to March 1988.

Formation of Concepts

The science curriculum and most often the class subject matter is often guided by the textbooks in use in any particular school system. However, science textbooks usually do not include information that could make the teacher more aware of possible misconceptions or preconceptions that students may encounter during a lesson or that a child may possess prior to the lesson. These preinstructional alternative conceptual frameworks, when at a variance with accepted scientific theory may play a crucial interfering role in learning science (Nassbaum, Novick, 1982). Any misconceptions or preconceptions that students have internalized are very resistant to change despite formal instruction. While there are many good science teachers using excellent teaching techniques, textbooks seldom describe adequate techniques that could be used to alter ideas to which children are strongly committed (Slinger, 1983). Teachers are not prepared to identify misconceptions nor do they have instructional strategies for dealing with these misconceptions. Most often teachers' questions are limited to seeking correct answers. Often teachers are not aware of the value that wrong answers contribute in diagnosing misconceptions.

Smith (1984) has outlined several categories of misconceptions. Misconceptions are defined as overwhelming sensory data which seem to prevent the student from assimilating a different model into their cognitive structure. Lawson defines misconceptions as knowledge derived from extensive personal experience which is incompatible with established scientific theory.

Smith (1984) identifies several kinds of misconception. Students may construct stunted conceptions (limited viewpoints) because students' memory space is inadequate for maintaining all the necessary factors and manipulating them at the same time. Students may also fail in linking external representations to underlying conceptual representation which Smith calls mistranslations. Also, a student may have confused conceptions in which the student confuses everyday language understandings with scientific definitions for the same words. Metaphors and analogies are complete systems of explanations that are sometimes scientifically unacceptable; these are known as true misconceptions. Preconceptions are notations that students possess based on their personal experiences which are often very limited and naive. No matter how misconception or preconceptions are defined, whenever students possess them, they can interfere with learning related material.

Many times the teacher is unaware of how the students have internalized the information from a classroom demonstration. Quite often the teacher does not sense something has gone amiss and fails to recognize those students who have not grasped the concept. Closer examination of a typical demonstration often done in classrooms to illustrate the water cycle can lead one to understand how students miss concepts, and how very difficult it is for a teacher to address all misconceptions. It is especially difficult if the teacher is not anticipating the students' ability to misinterpret the intent of the lesson.

A common lesson on the water cycle can be used to illustrate ways a student may perceive the concept presented. First you begin by placing a pan of water on a hot plate to let it boil. You would then wait and watch the water. As the water begins to boil you begin explaining the process of evaporation. Then you watch the water droplets form on the side of a jar that contains ice and call the droplets condensation. During this lesson the student may have visually lost you when the bubbles began to form in the water. These students may have been distracted by some special feature during the demonstration, and due to their limited memory space have problems switching back and forth among the water, rising vapor, and teacher's explanation (Smith, 1984). If the child attends to the teacher's explanation he learns that heat is what makes water boil and vapor rise. The child's current understanding of heat and temperature is based on the caloric, not the kinetic model, so the child may conclude that "heat" particles are escaping into the air, which is the beginning of a misconception (Smith, 1984).

As the child is visually attending to the demonstration the student must also attend auditorially. The students are required to switch their attention back and forth between the visual display and the explanations being given. If the child's attention is focused on the boiling, he possibly misses parts of the lesson. Students' connotation of words are often quite different than scientific definitions for the same words. While the student struggles to attend to both visual and auditory information, he is unable to grasp all the new terms and meanings.

Students may have difficulty in relating objects used during demonstrations with their real world counterparts, such as a pan of water representing a pond, stream, or lake. There is also difficulty relating their observations of evaporating water or the forming of water droplets a few feet in front of them and the actuality of it happening over great distances outside. It is further complicated by relating the whole process that has just taken a few minutes to a process that actually takes a much longer period of time. The students are asked to internalize this and manipulate the information into how the water cycle works. It seems that there are many areas that need attending when teaching a simple science lesson. Because this involves a great deal of manipulating information and visualizing, the question arises -- when should these concepts be presented?

Lawson and Renner state that according to the Piagetian model, formal thought begins at age 11 or 12 and reaches stability around age 15 or 16. Concrete operational people are unable to develop understanding of abstract concepts. This model also implies that formal-operational people are able to develop understanding of both concrete and abstract concepts. Lawson and Renner (1975) believe that concrete-operational individuals develop the ability to verbalize about concrete concepts but are denied full comprehension of the concept until development of formal operation.

After having conducted an investigation of developmental levels of learners, Lawson and Renner (1975) suggest that a substantial portion of secondary school science subject matter may not be suitable in terms of the intellectual level of the learner. They suggest that perhaps elementary and junior high students be confronted with first-hand experiences and concrete problems, which would aide in developing formal operational thinkers. Because much conceptual knowledge is lacking, incomplete, or unconnected, children's attempts to reconstruct memory models fail; students and teachers often opt for recognition of visual models and productions of appropriate words as evidence of knowledge construction (Smith, 1984). This is seen in the classroom quite often. Teachers assumes a concept has been learned when association can be made between word and objects or words and other words. Osborne and Cosgrove (1983) found that frequently pupils' understanding of scientific terms were superficial despite the fact that they could often associate correct technical terms with an event or phenomenon. This level of understanding could permit answering written test questions accurately, but without comprehension. Students have been conditioned to recognize correct responses without really being able to understand and relate concepts to the everyday world.

Teaching Strategies

Posner (1982) believes that learning is the result of the interaction between what the student is taught and his current ideas or concepts. Learning is concerned with ideas, their structure, and the evidence for them. Learning is not just a set of correct answers. However, the teaching of new science concepts must involve an inquiry into how students use their existing concepts to deal with new phenomenon being introduced. Will students' concepts change, how will they change, and what will be involved in changing their concepts?

Quite often students resist changing their preconceived notions despite formal instruction. The students need a new way of seeing the world. Internalizing is basic to understanding the subject matter. Posner (1982) outlines four conditions that must be met before students are likely to accommodate a new concept. There first must be a dissatisfaction with their existing concept. The students must have lost faith in the capacity of his current concepts to solve unsolved puzzles. Second, the new concept must be intelligible and the students then must achieve a minimal understanding of the scientific conception to explore the possibilities inherent in it. Third, the new scientific concept must appear plausible by having the capacity to solve problems generated. Finally, the students must see the new scientific concept as useful in a variety of situations.

Nassbaum and Novick (1982) report that students' preinstructional alternative framework often interferes with learning science, especially when students retain preconceptions and continue to use their preconceptions, which quite often have different meanings than the teacher intended. They reported that often students are satisfied with their preconceptions and that pupils are unaware there is a gap between meanings. Students are very content with their preconceptions because they work in the world as they perceive it.

Nassbaum and Novick say that the first step in enlightening students to their conflicting preconceptions begins with "an exposing event". This is a phenomenon which has been carefully selected to evoke students' preconceptions and provide the students with the opportunity to explain in terms of their own preconceptions. This is the initial phase which is intended to expose the students' alternative frameworks, stimulate the students to sense a conflict, and encourage discussions of the different preconceptions with the classroom. Next the teacher should create a "discrepant event" which creates conflict between exposed preconceptions and some observed phenomenon which they can not explain. Nussabaum and Novick believe this would encourage the students to accept a new conceptual model more consistent with accepted scientific conceptions.

Mintzes and Arnaudin (1984) recommend very similar processes to encourage students to become dissatisfied with their own preconceptions. They found that change was likely to occur when a new concept possessed a greater number of the following attributes: (1) intelligible (is it understandable?), (2) plausible (is it consistent with existing concepts?), (3) fruitful (does it have explanatory or predictive power?). If the new concept possesses more of these attributes than the old concept, then change is likely. Mintzes and Arnaudin see the teacher as the facilitator of change. Their criteria for changing preconceptions was very similar to what Nassbaum and Novick outlined. First Mintzes and Arnaudin recommend creating a situation in which alternative interpretations may be made. Discussion should be used to clarify any competing views and to introduce discrepant or anomalous observations. The teacher should then assist students in accommodating and reorganizing cognitive structure.

In a study done by Beveridege (1985) findings indicate that recognizing and resolving conflicting cognitions is important. He also points out that young children, without having contradictions pointed out, hold on to conflicting ideas without recognizing the conflict. Osborne and Cosgrove's results support the findings which suggest that children will maintain nonscientific ideas over a variety of ages. The findings also support the idea that the popularity of certain views can change with age, and that some nonscientific ideas are more popular with older children. Often scientific models tend to be rather abstract for students and do not relate to everyday experiences. Unless students are supplied with a better alternative, it is very unlikely the pupils will replace their working concepts with the new concepts unless they become displeased with the old concepts.

Gilbert, Osborne and Freshen (1982) recommend the development of science curricula where assumptions are based on what they term "student dominance". This assumption recognizes children's science views as being strong and persistent. "Children's science" is defined as viewing the world and scientific terms through the view point of the child. They recommend an approach in which it would make the learner aware of another viewpoint, the scientist's view. By adapting this approach, it might facilitate the learner's needs and help the learner identify his own conflicting beliefs. If science teaching is to be based on this approach much more needs to be known about "children's science".

Lawson and Renner's (1975) research focused on students general lack of reasoning skills. He concluded that many high school and even college students do not develop the skills using important formal, hypothetical-deductive reasoning patterns beyond the very familiar and concrete contexts. He further concluded that instructional materials and methods do not exist to significantly increase the students' ability to successfully utilize these reasoning patterns. There needs to be improvement of reasoning skills to help resolve contradictory viewpoints in which reason and evidence are sought. A possible solution would be to include curricular materials in the elementary and junior high schools with firsthand experiences and concrete problems. Then they would be entering secondary school as formal thinkers able to comprehend abstract nature of the courses.

Lawson (1986) outlines three phases he terms "the learning cycle." It begins with the "exploration phase" through which students learn through their own reactions and actions in new situations. In the classroom, the students are given new materials to explore and an opportunity to raise new questions. Second, during "term introduction," all new terms that relate to the patterns discovered are introduced. Finally, "concept application" is required. The student now applies the new terms and/or reasoning patterns to additional examples. It may be necessary for some students to abstract the pattern from the concrete context and/or generalize it to other situations. Until a person can internalize both the pattern or the terms and abstract the pattern, learning has not taken place.

Three types of "learning cycles" are also outlined by Lawson: (1) descriptive, (2) empirical-inductive, and (3) hypothetical-deductive. The greatest difference between these are the degree to which students gather data in a descriptive fashion or initially set out to test a hypothesis in a controlled fashion. Within each of these learning cycles three phases can be identified. The descriptive cycle requires only concrete operational skills, the discovery and description of empirical patterns within a specific context (exploratory). The teacher then gives each discovery a name (term introduction). The pattern is then identified in additional context (concept application) without generating hypotheses to explain observations. The descriptive cycle is designed only to observe a small part of the world, discover a pattern of regularity, name it and look elsewhere for patterns. This cycle does not evoke heated arguments where alternatives are sought, but it does sharpen skills.

The empirical-inductive cycle involves reasoning that is termed transitional. Students discover, describe and empirical pattern in a specific context (exploration). However, they proceed by generating possible causes for that pattern. This requires the transfer of terms/concepts learned, into other contexts (term introduction). Students sift through the gathered data to hypothesize if causes are consistent with those data and other known phenomena (concept application). During this cycle there is opportunity for many misconceptions to arise exposing conflicting concepts. This provides the basis for promoting disequilibrium and the development of conceptual knowledge and reasoning patterns.

The last type of learning cycle, hypothetical-deductive, demands the use of formal operational skills. This is introduced with an initial statement of a casual question to which students are asked to generate possible answers (hypotheses). Students spend time deducing logical consequences of these hypotheses, designing, and conducting experiments to test them (exploration). Then the students analyze their results to determine if the results prove or disprove the hypotheses (term introduction). Finally, students use relevant concepts and reasoning patterns to be applied in other situations (concept application). This is a very involved cycle in which the explanation of some phenomena could generate alternative concepts-misconceptions and disequilibrium leading to arguments and analysis of data to resolve conflicts. Students must initiate formal reasoning skills to deductively test hypotheses. Lawson believes that the learning cycle method of instruction is an effective way of helping students develop reasoning skills and helping students to acquire a set of scientifically valid concepts.

Conceptual Obstacles to Effective Teaching

Teachers need help in recognizing the clues that students give to signal a misunderstanding or misconception during laboratory activities, questions, and discussions. Teachers need experience in these areas as illustrated in a study conducted by Frances Lawrenze (1986) of elementary teachers with positive attitudes toward science. The study found that these same teachers may not have had an adequate background in the physical sciences. Teachers reported in this study had strong educational background with 47% having master's degrees. The teachers demonstrated misconceptions in several areas tested, such as mass relating to gases, motion and the nature of electromagnetic phenomena.

Smith and Lott (1983) found critical elements that had been omitted by teachers from their instruction. Smith and Lott outlined four aspects common to instructions: (1) experimental ambiguity, (2) ambiguity in discourse, (3) loose framing of important issues, and (4) attacking wrong perceptions. During the study designed to show how green plants obtain food, fifth grade students were shown activities and told the results of these activities dealing with plant sources of food and the role of light in plant growth, yet students were still unable to understand how plants get food or the role of light in plant growth.

One example of empirical ambiguity during the lesson dealing with plants occurred when students failed to recognize that the seed embryo develops into a plant only if attached to a cotyledon. Failure to understand this concept was attributed to individuals observing only their own experimental set up during the activity and because they ignored other experimental evidences when presented by other groups. Students also had difficulty judging significance of differences in embryo growth. Empirical ambiguity was also experienced when dealing with the role of light. While many of these missed concepts might have been dealt with, the teacher often failed to recognize the students' ambiguous ideas.

Ambiguity in discourse was the second area in which teachers were unable to recognize conflicting ideas. Confusing concepts were discussed but the teacher did not isolate the subtle concept that was being presented during the demonstration and discussion. The emphasis during the lesson was to find if the embryo grows. The subtle concept underlying the investigation was to find the function of an isolated embryo and an isolated cotyledon as well as their function as part of the seed. The teacher failed to recognize students' responses that indicated alternative conceptions on the part of the students.

The teacher neglected to recognize times when appropriate use of questions would have emphasized important issues. Often the teacher would attack the wrong preconception; the instructor would address only superficial aspects of preconception. A more direct attack on the underlying basis was needed but was not recognized. The teacher used in this study was considered an experienced, good teacher. One implication of the study seems to be that if an experienced teacher fails to interrupt misconception, most teachers may be making similar judgment errors. If teachers are to be more aware of alternative frameworks (misconceptions) children possess, then greater coverage is needed in preservice teacher education, and inservice as well as inclusion in teacher guides to textbooks.

Some researchers (Smith 1982, Osborne and Cosgrove 1975) suggest that the age at which we teach science concepts is important. Some concepts should be taught at an older age when students' memory capacity is better equipped to maintain and manipulate all the necessary factors. Younger children's abilities to mentally represent events happening during a demonstration, construct functional rules for those events, coordinate rules and then manipulate events to explain unseen real life events may be to overtaxing for the students. Osborne and Cosgrove suggest introducing ideas at an age when children are interested and searching for an explanation. They suggest teaching sophisticated concepts to students who do not have a real understanding of basic scientific concepts is of little benefit.

Obviously when teaching science, identifying preconceptions and misconceptions is very difficult. But, once identified, preconceptions and misconceptions must be resolved. If we are to attack this problem, researchers, textbook authors, curriculum developers, teacher educators, as well as classroom teachers will need to be informed. Inservice education in identifying and accommodating conceptual styles is needed. There is a need to have more effective teacher training programs. Curriculum developers and textbook writers need to be more aware of predictable alternative conceptions and identify appropriate questions.

Until educators become more aware of alternative conceptions and gain proficiency in identifying clues that help recognize misconception, conceptual change is not likely to occur. Not all the responsibility lies with the teacher. Research is needed to identify the pupils' alternative concepts and in general take a closer look at children's learning of science. Then we can provide the teacher with more effective teaching strategies, better prepared textbooks, curricula and teaching methods that are more congruent with the students' learning abilities.

CHAPTER III

METHODOLOGY

Introduction

The principal purpose of this chapter is to describe the methods and the procedures followed in conducting this study. Included in this chapter are the descriptions of the population studied, the development of the Water Cycle Assessment Test (WCAT), the procedures for collecting the data, and the method of analyzing the data.

Description of the Population

The students who participated in this study were from the Claremore Public Schools in Oklahoma. Claremore is located 20 miles northeast of Tulsa, Oklahoma. The population of the town itself is predominately Caucasian with a small population of blacks and a sizeable population of Native Americans. Claremore has three elementary schools, a middle school, a junior high, and a high school. Class sizes vary from 18-28 students.

The population for this study consisted of 4th, 6th, and 8th grade students. A total of 537 students were tested, 174-4th graders, 190-6th graders, and 173-8th graders.

Of the total population 269 were girls, 265 were boys; 3 students made errors in marking the answer sheets, so they were not identified as male or female. The tests were administered by the students' homeroom teacher or by the students' science teacher.

Development of the Instrument

The first step in the preparation of the Water Cycle Assessment Test (WCAT) was to make a survey of water cycle concepts contained in two commonly used science textbooks, published by Silver Burdett (1983) and Heath (1983). WCAT test items were obtained from the textbooks. In addition, questions were developed from a water concept interview used in research done by McJunkin (1988, unpublished dissertation). In some cases it was necessary to modify test items obtained from these sources; in other cases, items were created. Prior to the completion of the instrument two Oklahoma State University faculty members knowledgeable of water concepts were asked to evaluate and compare the continuity between the WCAT's questions and the McJunkin questions. Faculty input regarding the WCAT's questions was utilized and revisions were made to increase content validity. The WCAT contains twenty three multiple choice questions (Appendix A).

To establish reliability and further validate the WCAT a pilot study was conducted. The pilot WCAT was administered to students in Tahlequah Public School in Tahlequah, Oklahoma. The WCAT was given to one class of 4th, 6th, and 8th grade students in the month of December, 1987. The students were asked to answer all questions by selecting the most appropriate response, and were told that this exam was not related to their school grade. Teachers who administered the test during the pilot study indicated that pupils did not have difficulty understanding test question. This provided additional content validity. A .70 and above is considered a satisfactory reliability coefficient. The reliability of both the 4th and 6th grade test was .70. The 8th grade test reliability coefficient was .68 just slightly under the acceptable range.

Collection of Data

After the WCAT was determined to be a valid and reliable test, it was distributed to 4th, 6th, and 8th grade teachers in Claremore. Teachers were given a written instruction sheet (Appendix B) outlining information that was needed from the student. Students were asked to identify their sex, age, and grade; and to indicate if they had participated in extra activities such as Future Farmers of America, Future Homemakers of America, Girl Scouts, Boy Scouts, Campfire Girls or outdoor summer science camps. Each teacher was given the reading stanine score for their students if it was available and this was then recorded on the answer sheets.

The tests were administered during two time periods; in December 1987 and January 1988. In each period the tests were delivered on Monday and picked up on the Friday of that week. Due to the large number being tested and the number of available WCAT tests, not all tests were given during one sitting.

Textbook Analysis

A survey was made of the final chapter test and end of chapter review questions of textbooks currently used by the students being studies; Silver Burdett - 3rd, 4th, and 5th; Heath - 4th, 5th, 7th and 8th. A list of questions dealing with water cycle concepts was complied. The questions were then divided into those questions dealing with evaporation, condensation, and molecular motion.

Analysis of Data

The data from the WCAT test were computed and analyzed by the Oklahoma State University computer service. The WCAT was scored and stanine scores were produced. A Pearson Correlation Coefficient was used to measure the mean reading stanine with the mean WCAT stanine and to measure significant differences of reading levels for HO1, HO1a, HO1b, and HO1c. Duncan's Multiple Range Test for Variability was used with HO2, HO2a, HO2b, and HO2c to measure the significance between grade level and mean score of students on the various water concepts. The Duncan's

Multiple Range Test was used to measure significant difference between grade levels and mean WCAT scores for H03. A 0.05 level of significance was used to reject the null hypothesis. A t-test was used to measure the significance of mean scores of H04 and H05.

CHAPTER IV

PRESENTATION OF DATA

This chapter presents the findings generated from the testing of the hypotheses of the study. The chapter presents the description and the results of the testing of the hypotheses.

Descriptive Data

There was a total of 537 students tested in this study. The population for this study consisted of 4th, 6th, and 8th grade students. Of the total population 174 students were 4th graders, 190 were 6th graders, and 173 students were 8th graders. All students were given a 23 item test (Appendix A) focusing on the water cycle (Water Cycle Assessment Test).

Mean score for students in the 4th grade on the WCAT was 8.95 (38.9%). The high score for the 4th grade students was a 17 (73.9%). The low score was a 0 (0%). The distribution of scores, percent correct and relative frequency of all 4th grade students tested is shown on Table I.

TABLE I

FREQUENCY DISTRIBUTION OF
4TH GRADE WCAT SCORES

Correct Scores	Percent Correct	Relative Frequency
23	0.0	0
22	0.0	0
21	0.0	0
20	0.0	0
19	0.0	0
18	0.0	0
17	73.9	2
16	69.6	3
15	65.2	3
14	60.9	8
13	56.5	8
12	52.2	13
11	47.8	19
10	43.5	18
9	39.1	28
8	34.8	15
7	30.4	10
6	26.1	16
5	21.7	19
4	17.4	7
3	13.0	1
2	8.7	2
1	4.3	1
0	0.0	1
Total		174

Sixth grade students' mean score was a 10.32 (44.8%). The high 6th grade score was a 19 (82.6%). Low score for the 6th grade was a 1 (4.3%). The distribution of 6th grade scores, percent correct, and relative frequency are shown in Table II.

TABLE II

FREQUENCY DISTRIBUTION OF
6TH GRADE WCAT SCORES

	Correct Scores	Percent Correct	Relative Frequency
	23	0.0	0
	22	0.0	0
	21	0.0	0
	20	0.0	0
	19	82.6	3
	17	73.9	2
	16	69.6	4
	15	65.2	11
	14	60.9	11
	13	56.2	14
	12	52.2	22
	11	47.8	29
	10	43.5	21
	9	39.1	16
	8	34.8	15
	7	30.4	20
	6	26.1	8
	5	21.7	7
	4	17.4	5
	3	13.0	1
	1	4.3	1
	0	0.0	0
Total			190

The distribution of 8th grade scores, percent correct and relative frequency of WCAT scores is represented in Table II. The highest 8th grade score was a 22 (95.7%) which the low score was a 4 (17.4%). Eighth graders' mean score was a 11.18 (48.6%). Score ranges, high score and mean scores of 4th, 6th, and 8th grade are presented in

Table IV. As depicted in Table IV as grade level increases so do scores.

TABLE III

FREQUENCY DISTRIBUTION OF SCORES
OF 8TH GRADE WCAT SCORES

Correct Scores	Percent Correct	Relative Frequency
23	0.0	0
22	0.0	0
21	0.0	0
22	95.7	1
20	87.0	1
19	82.6	6
18	78.3	4
17	73.9	4
16	69.6	12
15	65.2	9
14	60.9	8
13	56.5	13
12	52.2	22
11	47.8	13
10	43.5	17
9	39.1	18
8	34.8	12
7	30.4	11
6	26.1	12
5	21.7	7
4	17.4	3
3	0.0	0
2	0.0	0
1	0.0	0
0	0.0	0
Total		173

TABLE IV

MEAN SCORES AND RANGE BY GRADE LEVEL

	Range	$\bar{x}$	% Correct
4th Grade	1-17	8.9	38
6th Grade	1-19	10.32	44
8th Grade	4-22	11.18	48

Research Questions and Hypotheses

Question 1 - Is there a relationship between pupil reading levels (standardized test data) and scores on the WCAT?

HO1 There is no significant relationship between 4th, 6th, and 8th grade pupils' reading level stanine on the Metropolitan Achievement Test (MAT) and water knowledge stanine on the WCAT.

The number of students, the mean MAT reading stanine scores, the mean water knowledge scores on the WCAT, and the standard deviation of all students are shown in Table V. The Pearson Correlation Coefficient was used to measure the strength of the relationship between the mean scores of the MAT reading level stanine and the WCAT water knowledge stanine reported in Table V. As indicated by the Pearson Correlation in Table VI, using a 0.05 level of significance the mean scores of the MAT reading level stanine and the WCAT water knowledge stanine are positively correlated. Since the value of .32 was produced and the level of significance is 0.0001, the correlation coefficient is considered significant thus the null hypothesis is rejected.

TABLE V

MEAN AND STANDARD DEVIATION FOR READING AND WATER KNOWLEDGE SCORES FOR ALL STUDENTS

	N	$\bar{x}$	Standard Deviation
Reading Score	528	4.69	2.84
Water Knowledge Score	537	4.91	1.98

TABLE VI

PEARSON CORRELATIONS COEFFICIENT OF MEAN READING STANINE AND WATER KNOWLEDGE STANINE FOR ALL STUDENTS

	N	Reading	N	Water Knowledge
Reading Score	528	1.00 0.00*	528	0.32 0.0001*
Water Knowledge	528	0.32 0.0001*	537	1.00 0.00*

*p < .05

HO2 There is no significant relationship between 4th grade pupils' reading level stanine on the MAT and the water knowledge stanine on the WCAT.

The number, mean score, and standard deviation is reported in Table VIII. The Pearson Correlation Coefficient was used to measure the strength of the relationship between 4th grade mean scores of the MAT reading level stanine and the WCAT water knowledge stanine reported in Table VIII. The Pearson Correlation Coefficient was calculated for 4th grade mean reading stanine and the mean water knowledge score using a 0.05 level of significance. The value of .26 at a 0.006 level of significance was computed and reported in Table VIII. This indicated a significant positive correlation between mean stanine scores thus the null hypothesis is rejected.

TABLE VII

MEAN AND STANDARD DEVIATION FOR READING AND WATER KNOWLEDGE SCORES OF 4TH GRADE STUDENTS

	N	$\bar{x}$	Standard Deviation
Reading Score	169	4.25	2.93
Water Knowledge Score	174	4.26	1.83

TABLE VIII

PEARSON CORRELATION COEFFICIENT OF MEAN READING STANINE AND WATER KNOWLEDGE STANINE OF 4TH GRADE STUDENTS

	N	Reading	N	Water Knowledge
Reading Score		1.00 0.00*		0.26 0.0006*
	169		169	
Water Knowledge		0.26 0.0006*		1.00 0.00*
	169		174	

*p < .05

HO1b There is no significant relationship between 6th grade pupils' reading level stanine on the MAT and the water knowledge stanine on the WCAT.

The number, mean score, and standard deviation is presented in Table IX. The Pearson Correlation Coefficient was used to measure the strength of the relationship between the mean reading stanine scores and the WCAT water knowledge stanine of 6th grade students as reported in Table X. Reported in Table X is the Pearson Correlation Coefficient of the mean reading stanine scores and the mean water knowledge score for using a 0.05 level of significance. A value of 0.43 at a 0.0006 level of significance was calculated. This indicated a significant positive correlation between mean stanine scores thus the null hypothesis is rejected.

TABLE IX

MEAN AND STANDARD DEVIATION FOR READING AND WATER KNOWLEDGE SCORES OF 6TH GRADE STUDENTS

	N	$\bar{x}$	Standard Deviation
Reading Score	188	5.30	2.50
Water Knowledge Score	190	5.01	1.86

TABLE X

PEARSON CORRELATION COEFFICIENT OF MEAN READING STANINE AND WATER KNOWLEDGE STANINE OF 6TH GRADE STUDENTS

	N	Reading	N	Water Knowledge
Reading Score		1.00 0.00*		0.43 0.0001*
	188		188	
Water Knowledge		0.43 0.0001*		1.00 0.00*
	188		190	

*p < .05

H01c There is no significant relationship between 8th grade pupils' reading level stanine on the MAT and the water knowledge stanine on the WCAT.

The number, mean score, and standard deviation is summarized on Table XI. To measure the strength of the relationship between the mean reading scores and the WCAT water knowledge scores the Pearson Correlation Coefficient was used. Reported in Table XII is the Pearson Correlation Coefficient of the mean reading stanine scores and the mean water knowledge stanine scores using a 0.005 level of significance. A value of 0.27 at a 0.0003 level of significance was calculated. This indicates a significant positive correlation between mean stanine scores thus the null hypothesis is rejected.

TABLE XI

MEAN AND STANDARD DEVIATION FOR READING SCORES AND WATER KNOWLEDGE SCORES OF 8TH GRADE STUDENTS

	N	$\bar{x}$	Standard Deviation
Reading Score	171	4.44	3.01
Water Knowledge	173	5.47	2.08

TABLE XII

PEARSON CORRELATION COEFFICIENT OF MEAN READING STANINE AND WATER KNOWLEDGE STANINE OF 8TH GRADE STUDENTS

	N	Reading	N	Water Knowledge
Reading Score		1.00 0.00*		0.27 0.0003*
	171		171	
Water Knowledge		0.27 0.00*		1.00 0.00*
	171		173	

*$p < .05$

Question 2 - At which grade level do pupils better understand various water cycle concepts?

HO2 There is no significant difference in mean scores of 4th, 6th, and 8th grade students on question dealing with evaporation (concept 1), condensation (concept 2), and molecular motion (concept 3).

To determine significant difference in mean scores of all the students tested on the different questions dealing with evaporation, condensation, and molecular motion, Duncan's Multiple Range Test was calculated. Groupings with same letters are not significantly different, groupings with different letters are significantly different as represented on Table XIII. A 0.05 level of significance was used.

All groupings are significantly different represented by different letters for each concept for all students as shown in Table XIII. This data is sufficient to reject the null hypothesis.

TABLE XIII

DUNCAN'S MULTIPLE RANGE TEST COMPARING MEAN SCORES FOR CONCEPTS 1-2-3 FOR ALL STUDENTS

Concept	$\bar{x}$	N	Duncan Grouping
1-Evaporation	2.46	537	A*
3-Molecular Motion	2.20	537	B*
2-Condensation	1.61	537	C*

*$p > .05$

HO2a There is no significant difference in mean scores of 4th grade students on questions dealing with evaporation (concept 1), condensation (concept 2), and molecular motion (concept 3).

Duncan's Multiple Range Test was calculated to determine significant difference in mean scores of 4th grade students tested on the different questions dealing with evaporation, condensation, and molecular motion. Groupings that have same letters are not significantly different from each other, groupings with different letters are significantly different, and are represented in Table XIV.

Mean scores of 4th grade pupils for concept 1 and concept 3 are not significantly different while responses for concept 2 is significantly different than both concept 1 and 3 as presented in Table XIV. However, the hypothesis is rejected on the basis that all three concepts are not significantly different.

TABLE XIV

DUNCAN'S MULTIPLE RANGE TEST COMPARING MEAN SCORES FOR CONCEPTS 1-2-3 FOR 4TH GRADE STUDENTS

Concept	$\bar{x}$	N	Duncan Grouping
1-Evaporation	2.17	174	A*
3-Molecular Motion	2.11	174	A*
2-Condensation	1.36	174	B*

*p > .05

HO2b There is no significant difference in mean scores of 6th grade students on questions dealing with evaporation (concept 1), condensation (concept 2), and Molecular motion (concept 3).

Duncan's Multiple Range Test was calculated to determine significant difference in mean scores of 6th grade students tested on the different questions dealing with evaporation, condensation, and molecular motion. Groupings that have same letters are not significantly different, groupings with different letters are significantly different and are represented in Table XV.

All three concepts are significantly different thus the null hypothesis is rejected.

TABLE XV

DUNCAN'S MULTIPLE RANGE TEST COMPARING MEAN SCORES FOR CONCEPTS 1-2-3 FOR 6TH GRADE STUDENTS

Concept	$\bar{x}$	N	Duncan Grouping
1-Evaporation	2.62	190	A*
3-Molecular Motion	2.22	190	B*
2-Condensation	1.56	190	C*

*p > .05

HO2c There is no significant difference in mean scores of 8th grade students on questions dealing with evaporation (concept 1), condensation (concept 2), and molecular motion (concept 3).

Duncan's Multiple Range Test was calculated to determine significant difference in mean scores of 8th grade students tested on the different questions dealing with evaporation, condensation, and molecular motion. Groupings that have same letters are not significantly different, groupings with different letters are significantly different and are represented in Table XVI.

All three concepts are significantly different thus the null hypothesis is rejected.

TABLE XVI

DUNCAN'S MULTIPLE RANGE TEST COMPARING MEAN SCORES FOR CONCEPTS 1-2-3 FOR 8TH GRADE STUDENTS

Concept	$\bar{x}$	N	Duncan Grouping
1-Evaporation	2.56	173	A*
3-Molecular Motion	2.26	173	B*
2-Condensation	1.90	173	C*

*p > .05

Question 3 - Do 4th, 6th, or 8th grade pupils have a greater understanding of water cycle concepts?

HO3 There is no significant difference between 4th, 6th, and 8th grade mean WCAT scores.

Duncan's Multiple Range Test was used to determine significant difference between 4th, 6th, and 8th grade mean WCAT scores. To represent significant difference grouping have different letters, groupings with same letters are not significantly different. A 0.05 level of significance was used.

It was found that 8th graders' and 6th graders' scores were not significantly different as presented in Table VII. However, 4th graders' mean scores were lower and significantly different. The hypothesis is rejected on the basis that all three grades did not score significantly different.

TABLE XVII

DUNCAN'S MULTIPLE RANGE TEST COMPARING MEAN WCAT SCORES OF 4TH, 6TH, AND 8TH GRADE STUDENTS

Grade	$\bar{x}$	N	Duncan Grouping
8	11.37	127	A*
6	10.63	164	A*
4	9.10	125	B*

$*p > .05$

Question 4 - Is there a difference in mean WCAT scores for students who have participated in out-of-school activities, i.e.: 4-H, Scouts, or summer camps? Are water concepts learned in or out of school?

HO4 There is no significant difference in mean WCAT scores of pupils who have and have not participated in Scouts, 4-H, or summer outdoor camping programs.

A t-test was used to determine significant difference in mean WCAT scores of pupils who have and have not participated in extra curricular activities. Table XVIII shows no significant difference exists between mean scores of students who have and have not participated in extra curricular activities. The students with out of school activities did, however, have a higher average. Based on these results in Table XVIII the null hypothesis was not rejected.

TABLE XVIII

T-TEST COMPARING MEAN WCAT SCORES OF STUDENTS THAT HAVE AND HAVE NOT PARTICIPATED IN EXTRA CURRICULAR ACTIVITIES

Activity	N	$\bar{x}$	Standard Deviation	T	Prob > T
Have Not	164	10.13	3.65		
Have	250	10.55	3.45	.41	.24*

*p > .05

Question 5 - Do male or female pupils have greater understanding of water cycle concept?

HO5 There is no significant difference between mean male and female WCAT scores.

The t-test values comparing mean differences in male and female mean WCAT scores are shown in Table XIX. Reported are mean, standard deviation, and level of significance. A 0.05 level of significance was used to reject the null hypothesis.

The data in Table XIX indicates that there is a significant difference in male and female scores at the .0028 level with females having the higher average! Therefore, the null hypothesis is rejected.

TABLE XIX

T-TEST COMPARING MEAN WCAT SCORES OF MALE AND FEMALE STUDENTS

Sex	N	$\bar{x}$	Standard Deviation	T	Prob > ltl
Male	202	9.87	3.30	.1	0.0028*
Female	212	10.90	3.69		

*p > .05

Question 6 - At which grade level are concepts introduced in textbooks?

As indicated in Table XX, students taught from the Silver Burdett and Heath series are not heavily tested on the condensation concept of the water cycle, however, molecular motion is stressed throughout the grades. Evaporation is stressed in the lower grades, it then appears evaporation is minimized. It appears that condensation is mainly addressed in the seventh grade, this being the only time condensation is stressed. This would tend to indicate a lack of emphasis in textbooks over the condensation stage of the water cycle.

It was noted while surveying the textbooks that topics such as ground water and fresh water was found more often in the upper level Heath books. The author also noted that while surveying the textbooks; molecular motion was often discussed in great detail in the chapters in the 3rd grade textbook.

TABLE XX

NUMBER OF QUESTIONS ON WATER CYCLE CONCEPTS IN TEXTBOOKS BY GRADE

Grade Level	Concept 1 Evaporation	Concept 2 Condensation	Concept 3 Molecular Motion
3	3	1	1
4	2	1	7
5	2	1	5
7	1	3	3
8	1	0	2

Question 7 - What relationship exists between water concepts correctly identified on the WCAT and those correctly identified during a structured interview?

Questions 8, 11, 12, 15, 16, 17, 18, 19, 20, 21, 22 and 23 from the WCAT (Appendix A) were the same questions McJunkin (McJunkin, 1988) used during his interview with 4th, 6th, and 8th grade students. Responses were compared to determine if similarity exists between students verbal understanding of concepts and their ability to correctly respond on written test or whether similar misunderstanding occur.

Students' answers during McJunkin's interview were recorded as; no response (NR), partial understanding (PU), sound understanding (SU), and specific misunderstanding (SM). Partial understanding was defined a response that included at least one of the components of a scientifically acceptable answer but not all the components. Sound understanding was defined as a response that includes all components of a valid answer. A response that included irrelevant, illogical, or incorrect information was considered a specific misunderstanding.

In an effort to compare students' responses and for the purpose of this paper students "partial understanding" responses during the interview were considered correct responses, as well as, responses that were classified as sound understanding in Table XXI. It should also be mentioned that in some cases answers that were scored as partial understanding were often very broad and very general. By grouping those interview answers in this fashion the number of correct interview responses have been inflated.

The percentage of correct responses for both the interview and the WCAT are shown in Table XXI. There were only five instances in which there was a higher percent of correct answers on the interview than on the WCAT. One question (#11) in which students did score lower on the WCAT dealt with evaporation. However, other questions (#12 and #15) concerning evaporation, students scored better on the WCAT. This could be possible confusion on word terminology or an indication of partial understanding of the concept.

Students on the interview were better able to show understanding for these concepts: gravity, melting, boiling, and freezing. It is important to reiterate that the interview was not a test and students were asked to explain the water concept being demonstrated. On these questions there were no students that demonstrated complete understanding of these terms. It would appear that students answering questions 20 (freezing) on the WCAT demonstrated very little understanding or a misconception of the concept.

As indicated on Table XXI, students generally had more percentages that were higher on the WCAT than on the interview (7 out of 12). However, students scored over 50% correct on seven of the questions during the interview while students on the WCAT scored over 50% on only 5 questions. A per item comparison does reveal that more students did better on the written test than on the oral test.

The two questions scored the very lowest during the interview were both questions about condensation (#8 and #16). While these questions were scored low on the WCAT they were not the lowest score. This may be an indication that students are learning survival skills without possessing the knowledge.

TABLE XXI

COMPARISON OF INTERVIEW AND WCAT CORRECT RESPONSES FOR ALL STUDENTS

Question	% Correct	
	Interview	WCAT
8 Condensation	8.7	37
11 Evaporation	70	60
12 Evaporation	55	74
15 Evaporation	61	68
16 Condensation	2	38
17 Gravity	84	53
18 Melting	72	35
19 Boiling	70	65
20 Freezing	79	18
21 Ground Water	35	37
22 Steam	46	49
23 Water Vapor	21	46

An interesting comparison was made between responses on the WCAT and the interview on two different questions. Question 8 was about condensation and question 11 was about evaporation. Students were unable to show much understanding of the concept condensation (Question 8), only one student demonstrated complete understanding and a total of 4 (7%) of the students for all three grades showing partial understanding as shown on Table XXII. While 193 (37%) of the total number of students on the WCAT chose the correct answer as opposed to 5 (8%) interviewed students. During the interview, only one fourth grade student demonstrated complete understanding of the concept. However, on the WCAT, a larger percentage of 8th grade students were able to chose the correct answer.

TABLE XXII

INTERVIEW AND WCAT RESPONSES OF
QUESTION 8 BY GRADE LEVEL

Grade	N	Interview Responses			
		NR (%)	SM (%)	PU (%)	SU (%)
4	22	6 (27)	13 (59)	2 (9)	1 (4)
6	23	2 (8)	20 (86)	1 (4)	
8	12	3 (25)	8 (66)	1 (8)	

Grade	N	WCAT Responses			
		a (%)	b (%)	c (%)	d (%)
4	170	42 (26)	22 (12)	42 (26)	64 (37)
6	190	50 (26)	12 (6)	72 (37)	56 (30)
8	174	38 (21)	10 (6)	46 (27)	78 (44)

NR - No Response, SM - Specific Misunderstanding, PU - Partial Understanding, SU - Sound Understanding

Question 8 - Water droplets form on the outside of a closed jar that contains an ice cold drink. Where does the water droplets come from?

a. from the cold water inside the glass
b. come through the glass and form on the outside of the glass
c. evaporation over the top of the glass and drips down the side of the glass
d. from the air outside the glass.

Students during the interview on question 11 in 4th and 6th grade had much higher percentages while 8th grade students on the WCAT had higher averages as shown on Table XXIII. In fact, on the WCAT as the grade level increases so does the averages. However, the interview shows that

8th grade students have the very lowest scores of the three grades. This would indicate an 8th grader is better able to read and answer questions correctly on a written test, but are unable to demonstrate verbal understanding of the concept.

TABLE XXIII

INTERVIEW AND WCAT RESPONSES OF QUESTION 11 FOR ALL STUDENTS

Grade	N	Interview Responses			
		NR (%)	SM (%)	PU (%)	SU (%)
4	22		5 (22)	17 (77)	
6	23		4 (17)	19 (82)	
8	12	4 (33)	4 (33)	4 (33)	

Grade	N	WCAT Responses			
		a (%)	b (%)	c (%)	d (%)
4	172	14 (8)	34 (20)	64 (37)	60 (35)
6	184	8 (4)	12 (6)	32 (16)	132 (72)
8	168	8 (4)	12 (7)	42 (14)	124 (73)

NR - No Response, SM - Specific Misunderstanding, PU - Partial Understanding, SU - Sound Understanding

Question 11 - What causes wet clothes on a line to dry?

a. the movement of water particles
b. the wind blowing
c. the sun shinning
d. all the above.

CHAPTER V

SUMMARY, FINDINGS, IMPLICATIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to identify concepts held by students in relation to the water cycle and related ideas. The writer attempts to identify factors related to learning outcomes of students and the implications this may have toward education.

Findings

The null hypothesis are presented in the same sequence directing the study with each hypothesis coded to the appropriate question. Based on the findings of this study, there is evidence to support the following conclusions:

HO1 The null hypothesis which stated that here was no significant relationship between reading level and water knowledge was rejected. It was shown that as reading level increased so did students' water knowledge. There is a positive relationship between reading scores and water knowledge.

HO1a The null hypothesis which stated that there was no significant relationship between 4th graders' MAT reading stanines and WCAT water knowledge stanine was rejected. Fourth graders demonstrated that there is a correlation between reading abilities and how well students did on the WCAT.

HO1b The null hypothesis which stated there was no significant relationship between 6th graders' MAT reading stanines and WCAT water knowledge stanine was rejected. Sixth grade students that there is a correlation between reading abilities and how well students did on the WCAT.

HO1c The null hypothesis was rejected as there was a positive correlation between 8th grade students MAT stanine score and WCAT stanine score.

HO2 The null hypothesis which stated there was no significant difference in mean scores of students on questions dealing with evaporation, condensation, and molecular motion was rejected. While each concept was scored significantly different it is interesting to note that the concept with the lowest score was condensation.

HO2a The null hypothesis which stated there was no significant difference in mean scores of 4th grade students on questions dealing with evaporation, condensation and molecular motion was rejected on the basis that not all three concepts were different. As indicated in Table XIV the concept of evaporation and molecular motion were not significantly different from each other. The concept condensation was found to be significantly different indicating a greater understanding of evaporation and molecular motion.

HO2b The null hypothesis was rejected as there was significant difference in 6th grade students scores on questions dealing with evaporation, condensation, and molecular motion. While all concepts were significantly different condensation, once again was lowest with evaporation and molecular motion having higher scores. This would imply that students are more familiar with the concept evaporation and molecular motion than with condensation.

HO2c The null hypothesis was rejected as there was significant difference in 8th grade students scores on questions dealing with evaporation, condensation, and molecular motion. All concepts were significantly different with condensation being the lowest. This establishes a trend that continues into the eighth grade in which condensation is the concept students are most unfamiliar with. This may indicate a consistent, however, low level of instruction in the area of condensation.

H03 The null hypothesis which stated that was no significant difference between 4th, 6th, and 8th grade students' mean scores on the WCAT was rejected on the basis that all three grades did not score significantly different. Eighth grade students scored the highest of the three grades followed by the 6th and then by the 4th. There was not a significant difference between the 6th and 8th grade scores, however, 4th grade students did score significantly different indicating that both 6th and 8th grade students are able to score better on the written WCAT test and a possible superior understanding of the concepts of the water cycle.

H04 The null hypothesis was not rejected as no significant difference in scores of students who have participated in extra curricular outdoor activities and those who have not. This would be an indication that students are not learning about the water cycle and related ideas outside the classroom. This would indicate that students are learning about water from textbooks and instruction in the classroom.

H05 The null hypothesis was rejected as there was a significant difference between male and females scores with females having the higher average.

This may indicate that females in elementary are better readers.

Question 6 - There is instruction in each of the 3 concepts; evaporation, molecular motion, and even condensation in the 3rd grade. However, it was also found that more emphasis by the textbooks is given to evaporation and molecular motion especially in grades 4 and 5. Students are introduced to evaporation as well as molecular motion in 3rd grade and apparently reinforced in grades 4 and 5. But little instruction is given in the higher grades on these very abstract concepts. While condensation, an equally important concept of the water cycle is not stressed until 7th grade and then only of 7th grade.

Question 7 - This study found that students seem to perform better on the written test as opposed to an oral interview. However, the overall performance on both evaluations did not indicate good mastery of the water cycle and related ideas. On questions that were compared, there were only five questions in which over 50% of the students scored the correct answer on the WCAT. While students percentages (above 50%) during the interview tended to be higher; less was required for a student to have scored partial understanding and to be considered a correct answer in this study. As an indication of this, there were only three questions (#12, #21, and #22) in which a small number of students demonstrated sound understanding of the concept during the interview. Inspite of this more questions were scored correctly on the WCAT.

Implications

This study may indicate that students doing well on written exams may not necessarily possess a superior knowledge of material tested but may just have a more sophisticated reading level, or may simply have a stronger sense of word recognition. Written testing may not necessarily be a measure of what students know. As seen during the interview students were often unable to describe a phenomenon and seldom demonstrated complete understanding of a concept even when observing the phenomena demonstrated.

An alarming deficiency of water concepts on the part of the study population was indicated by this study. The study revealed that overall knowledge was low. Students also exhibited comparatively less knowledge about the concept, condensation. A contributing factor to the low condensation scores may be a lack of emphasis on equally important concepts necessary to understand the water cycle and related ideas. This lack of emphasis stems in part from unequal treatment of concepts of the water cycle presented in textbooks. Teachers need to be aware that textbooks may not be placing equal emphasis on all aspects of water concepts necessary for full understanding of the water cycle. With this knowledge, teachers will be better able to compensate and supplement textbook materials.

All three water cycle concepts are very abstract concepts, yet they are introduced at a very early age. It is interesting that the concept that is understood the least is condensation. Condensation and molecular motion are both concepts that are mainly abstractions. Students seemingly have a better understanding of evaporation. Evaporation is the only concept that begins with something very concrete, i.e., liquid water. Lessons in textbooks begin working with molecular motion in the early grades and students seemingly are better able to handle this concept. However, condensation is a concept whose beginning starts with unseen water vapor and is very abstract. This initial abstraction may be an inhibiting factor to gaining better understanding of the concept condensation. The implications are that students need to experience in a concrete fashion whenever possible the concepts of evaporation, condensation and molecular motion in order to build appropriate mental models.

Apparently students approach the study of water and related concepts often with preconceived ideas or develop misconceptions. Many times these ideas are scientifically incorrect and inconsistent. Too often these incorrect ideas are not properly addressed in the curriculum and these affect learning outcomes. Teachers must recognize this road block to communication and deal with it in early as well as later grades.

As natural resources become more and more limited, basic knowledge of these resources is necessary. The significance of developing a firm foundation in basic concepts is fundamental in developing decisive and critical decision makers for the future. Although it has not been the purpose of this study to investigate children's knowledge of preserving natural resources, the need for such research is evident.

Recommendations

Several problems relation to educating young students in the science of water surfaced during this study. The writer proposes the following for curriculum development, classroom application and further study.

1. Textbook authors, curriculum developer and educators need to address possible preconception that students bring into the classroom. Classroom teachers need to be more aware of preconcepts the student possess. More research is needed to identify these preconceptions. More inservice is needed to help train teachers to recognize preconceptions.

2. Textbook authors, curriculum developers, teachers, as well as teacher educators need more information to better address and recognize misconceptions. A misconception may occur at any moment during a lesson. Classroom

teachers need to be trained to recognize student questions and responses that indicate the student possess a misconception. After the teacher recognizes a misconcept the teacher needs adequate training in altering a childs conceptual framework. This can be accomplished by providing the teacher with better prepared textbooks and more effective teacher training programs.

3. Teach for conceptualization by using tactical phenomenon whenever possible, especially with condensation.

4. Teachers should be cautious when structuring instruction to accomplish mastery of concepts where achievement is measured only with paper and pencil. Such instruction may encourage memorization and discourages conceptualization.

5. Pretesting in order to identify preconcepts as well as misconcepts would be beneficial. However, without proper training teachers would not be able to identify the alternative concept nor would the teacher be able to alter the concept.

6. All the water and water related concepts need to be stress equally. More concrete concepts, such as ground water are dealt with more often in higher grade level textbooks. While there is little emphasis on abstract concepts such as condensation. Perhaps a continuum stressing condensation needs to be presented throughout the grades.

7. Recommend verbal testing for low readers.

8. To make instructional material relevant

to the students, current environmental issues could be stressed.

9. A study using an experimental design, where subjects are assigned randomly to groups, is recommended to clarify the importance of concrete experience as opposed to the printed work to assess knowledge.

The overall outcome of this study indicates a frightening lack of knowledge concerning basic components of our habitat; water. If the data reported here is truly representative of children across our nation, it is possible that in the future we face a national crisis in the area of water resource management.

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APPENDIXES

APPENDIX A

QUESTIONNAIRE

Choose the best answer.

1. If a small saucer of water is placed on a window sill in the sunlight, after awhile the saucer it will be dry. What happens to the water that was in the saucer?

    a. It goes into the saucer
    b. It just dries up and no longer exists as anything
    c. It changes into oxygen and hydrogen into the air
    d. It goes into the air as very small bits of water

2. What will happen to the water particles in a pan of water sitting on the hot burner of a stove?

    a. The water particles fill with bubbles
    b. The water particles begin moving faster
    c. The water particles stop moving
    d. The water particles begin to move slower

3. When a pan of water boils there are bubbles in the water. What are the bubbles made of?

    a. Air
    b. Steam
    c. Heat
    d. Oxygen or hydrogen

4. What must be done to change a solid to a liquid or a liquid to a gas?

    a. Energy must be added to make the changes, usually heat energy
    b. Energy must be taken away to make the change
    c. Energy must be the same to make the change
    d. Nothing, the change just happens

5. If enough heat is added to liquid water, the water...

   a. Condenses
   b. Contracts
   c. Becomes a gas
   d. Becomes a solid

6. A solid changes to a liquid when...

   a. Water boils
   b. Ice cream melts
   c. A puddle dries
   d. Coffee perks

7. For rain to result from a cloud which must occur?

   a. Add heat only
   b. Take away heat only
   c. Add moisture and take away heat
   d. Add moisture only

8. Water droplets can form on the outside of a closed jar that contains an ice cold drink. Where do the water droplets come from?

   a. From the cold water inside the glass
   b. Come through the glass and form on the outside of the glass
   c. Evaporation over the top of the glass and drips down the side of the glass
   d. From the air outside the glass

9. When millions of tiny drops of water and bits of dust float together in the air...

   a. Clouds are formed
   b. The water cycle ends
   c. Snowflakes fall
   d. Dew is formed

10. What must be done to change a liquid to a solid?

   a. Energy must be taken away
   b. Energy must be added
   c. Energy must be the same
   d. Energy is neither added or taken away, it just changes

11. What causes wet clothes on the line to dry?

    a. The movement of water particles
    b. The wind blowing
    c. The sun shinning
    d. All of the above

12. As damp (not dripping wet) clothes line dry, where does the water go?

    a. It drips out
    b. It goes into the ground
    c. It goes into the air
    d. It just disappears

13. Most fresh water on earth is stored as...

    a. Water in the atmosphere
    b. Water in the oceans
    c. Water in the ground
    d. Water in ice

14. If you lived in North America before the white man came, from which of the following could you most safely drink water?

    a. A stream with fish, frogs, and plants
    b. Sewer
    c. A stream with no fish, frogs, and plants
    d. An ocean

Choose the best definition for each of the following words.

15. Evaporation

    a. The changing of a gas to a liquid
    b. The changing of a liquid to a gas
    c. The changing of a solid to a liquid
    d. The changing of a liquid to a solid

16. Condensation

    a. The changing of a gas to a liquid
    b. The changing of a liquid to a gas
    c. The changing of a solid to a liquid
    d. The changing of a liquid to a solid

17. Gravity

    a. The force of one object pushing another object
    b. The force of one object falling on another
    c. The force of one object moving another object
    d. The force of one object pulling another object

18. Melting

    a. Moving particles slow down and get closer together
    b. Moving particles stop moving and drift apart
    c. Moving particles disappear
    d. Moving particles speed up and move farther apart

19. Boiling

    a. Moving particles slow down and get closer together
    b. Moving particles stop moving and drift apart
    c. Moving particles disappear
    d. Moving particles speed up and move farther apart

20. Freezing

    a. Moving particles slow down and get closer together
    b. Moving particles stop moving and drift apart
    c. Moving particles disappear
    d. Moving particles slow down and move farther apart

21. Ground Water

    a. Water found underground in porous rock and gravel
    b. Water found in small ponds
    c. Any water found on the surface of the ground
    d. Water from natural springs

22. Steam

    a. Any vapor, fume, or mist
    b. Solid particles in a gas
    c. Water found in gas form
    d. Water that has disappeared never to be seen again

23. Water Vapor

   a. Any vapor, fume, or mist
   b. Solid particles in a gas
   c. Water found in gas form
   d. Water that has disappeared

APPENDIX B

INSTRUCTION FOR ADMINISTERING THE WCAT

Please ask students to fill out questionnaire over water cycle. Have students put student number in section that says student ID.

Under section called Course Number, 1st Column:

If students have ever belonged to FHA, Boy Scouts, Girl Scouts, Campfire, or gone to a science workshop or camp in the summer have them mark circle 1. If they have never participated in one of these activities, mark circle 0.

Under Course Number, 2nd Column:

If they are a <u>girl</u> have them fill in 0.

If they are a <u>boy</u> have them fill in 1.

Under Course Number, 3rd and 4th Column:

Fill in student age.

Under part labeled <u>section</u> have them put their grade (1st column). In the 2nd column under section have them put the number from the class that I have provided.

Your help is greatly appreciated!

D. Wilson

VITA

Dee Ann Wilson

Candidate for the Degree of

Master of Science

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